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THE SIGNIFICANCE OF CALCIUM FOR HIGHER GREEN PLANTS[1]

In view of the time limit reasonably set for this paper, I shall not attempt to review the very extensive literature that in one way or another deals with the relation of calcium to the plant world, but shall content myself with pointing out certain of the land marks that occur at certain intervals along this oft-traveled road. And, at the beginning, I may as well give Jost's summing up of the situation as he saw it in 1906, [2]when he says, "We are bound to admit that its function has not yet been discovered."

To Salm-Horstmar[3] seems to belong the credit of proving in 1856 that calcium is necessary for phanerogams and is distinctly not replaceable by magnesium.

Almost simultaneously in 1869 Adolph Mayer[4] and Raulin[5] showed that this rule was not of general application since certain non-chlorophyllose types were found to thrive without it.

Mayer grew yeast normally in media from which calcium was lacking and Raulin did the same with Aspergillus. It remained for Molisch[6] in 1895 to demonstrate that not all green plants require calcium by cultivating

[1]Address of the Vice-President and Chairman of Section G, Botanical Sciences, American Association for the Advancement of Science, Toronto, December, 1921.

[2]Jost, Ludwig, "Lectures on Plant Physiology," Gibson's transl. Oxford, 1907: 85.

[3]Salm-Horstmar, "Versuche und Resultate über die Nahrung der Pflanzen, Braunschweig." 1856.

[4]Mayer, Adolph, "Untersuchungen über Alkoholgährung." 1869: 44.

[5]Raulin, *Ann. d. Sci. Nat.*, V, Ser. I, 11: 224, 1869.

[6] Molisch, *Stizb. d. Wien. Akad.*, Abt. I, 104: 733. 1895.

certain algæ in media from which this element was absent.

In the meantime the distilled water problem had arisen to vex all physiologists and in their attempt to deal with it the zoologists had thrown some light on the calcium problem as well. Perhaps fundamental to all was the work of the English physiologist, Sydney Ringer, who, as a by-product of a long series of experiments, developed the generally-used normal saline solution known by his name. While working on the characteristic effects produced by various salts in prolonging the life of organisms in water cultures, he noted the favorable action of calcium salts.[7] He observed that in distilled water calcium and other salts were extracted from fish placed in it, and records that epithelial and mucous cells seemed to become detached from the gills. In later experiments carried out on Tubifex, a freshwater worm, he noted that a far more striking change took place. After a time spent in water from which calcium salts were excluded, the worms disintegrated. When to distilled water a calcium salt was added the worms not only lived but behaved very much as they did in river water.[8]

His explanation of the fundamental causes here operating was couched in rather general language, but one gathers that he conceived them to be of a physico-chemical nature, and the seat of operation was thought to be in the cells of the animals. There is much in Ringer's work to repay the student of general physiology.

The fundamental features observed by him were confirmed by Herbst in 1900[9], when he showed that in certain sea-urchin larvæ grown in sea water from which Ca was lacking, the epithelial tissues dissolved into their component cells. When these dissociated, but still living, elements were returned to calcium-containing sea water, they adhered again to each other at their points of contact. Herbst assumed that a *Verbindungsmembran* exists between the cells when Ca is present, that this membrane is dissolved when Ca is lacking in the external medium, thus releasing the cells of the complex. When Ca is restored, this membrane is reconstituted and again cements the cells at their points of contact.

It is interesting to note in connection with these observations of Herbst those of Knüdson,[10] who found that in Pfeffer's solution the root cap cells of corn and Canada field peas are sometimes sloughed and remain in the medium isolated but living for as long a period as seventy days or more. While it does not appear that a Ca shortage existed in these root cap cells, the possibility of such a shortage would be well worth investigating.

In 1905 and 1906, while engaged in a study of the physiological properties of distilled water, the author, with the kindly aid of his colleague, Dr. Lyman G. Briggs, applied the method of electrical conductivity to the investigation of ion changes in solutions in which seedlings were growing. It was observed that the conducting capacity of distilled water in which seedlings were grown increased, due, it was believed, chiefly to the leaching of ions from the cells of the seedlings. It was noted furthermore that this leaching was checked when a small quantity of a Ca salt was added to the distilled water.[11]

The use of the conductivity method was extended by H. H. Bartlett and the author[12] to a study of ion changes taking place in distilled water and in solutions of calcium nitrate and magnesium nitrate planted with pea seedlings. Owing to the fact that the method as applied to this type of work had not then been carefully studied, more attention was given here to the method. The conclusion was reached that equilibrium concentrations of Ca and NO_3 ions in one case and of Mg and NO_3 ions in the other instance existed for peas below which the roots would leach ions into

[7] Ringer, Sydney, *Journ. of Physiol.* 4: IV. 1883.

[8] Ringer, Sydney, and Sainsbury, H., *Journ. of Physiol.*, 16: 4. 1894.

[9] Herbst, C., *Arch. Entwicklungsmech* 9: 424. 1900.

[10] Knüdson, L., *Am. Journ. Bot.*, 6: 309. 1919.

[11] True, Rodney H., *Am. Journ. Bot.*, 1: 255-273. 1914.

[12] True, Rodney H., and Bartlett, Harley Harris, Bureau of Plant Industry, U. S. Dept. of Agri. Bull., 231: 1-36. 1912.

either solution, or into solutions containing both salts mixed in various proportions and above which the roots would absorb ions. It was shown that Ca differed essentially from Mg ions in being harmless in concentrations that proved fatal in the case of magnesium.

The conductivity method was next applied to the problem of absorption by phanerogamic seedlings from solutions of the ordinary nutrient salts; these being studied singly in various concentrations[13] and mixed in a variety of proportions and concentrations.[14] I will not try to deal here with the results gained beyond presenting a brief summary of such points as bear on the question now in hand. As a result of the study of several sorts of seedlings grown in solutions of single salts it may be said that in solutions of potassium and sodium salts no concentration was observed in which the seedlings were able to carry on sustained absorption, in the end yielding markedly more ions to the medium than they were able at any time to appropriate.

In solutions of Ca and Mg salts there was a well defined equilibrium concentration below which the roots were not able to absorb and in these sub-minimal solutions ions leached out into the medium. In solutions stronger than this equilibrium concentration, absorption took place in greater or less measure. It appeared that Ca was more favorable generally than Mg. At no concentration tried, the strongest being about 900×10^{-6} gram norm. per liter, was there any evidence of injury. Where the concentration of Mg was raised in order to ascertain the maximum quantity of absorption, characteristic injury appeared and death more or less promptly thereafter. A similar injury appeared tardily in weaker solutions on longer duration.

In mixtures again, absorption or leach depended on the presence of Ca or Mg ions. Again Ca in high proportion never brought injury. Mg injury appeared less often than in simple solutions. There was little evidence that any such thing as a very definite Ca-Mg ratio exists. In mixtures containing Ca and other nutrient ions, especially when all or a large proportion of the required ions were present, the total quantity of ions absorbed far exceeded the quantity of Ca ions present. This indicated that in such mixtures Ca ions in some way secured conditions that bring about the absorption of ions, that, offered in unmixed solutions, would be unabsorbed, or would cause an active leach of other ions from the plant cells.

Thus we may fairly say that the presence of Ca ions in some way makes those absorbable that would otherwise be unabsorbable and enables the plant to retain ions that it would otherwise be unable to retain. The Ca ions may be truly said to make the others *physiologically available* to the plant. Stating this in terms of the soil, we may say that when the required minimum of Ca ions is not present in the soil solution other nutrient ions present are largely out of reach and such a deficient soil solution may finally leach mobilized nutrients from seedlings. If the required minimum of Ca ions is not present, other nutrient ions may be present in abundance but be *physiologically unavailable* because of the inability of the plant to appropriate them.

Having thus far established the relation between Ca ions and the ability of the roots of the seedlings studied to retain ions gained by the mobilization of their reserves and to absorb others from the nutrient medium outside them, let us turn to a somewhat more detailed study of this phase of calcium action.

Analytical data have long since indicated a close chemical relation between the calcium-content of higher plants and the cell wall. The calcium content is relatively low in young meristematic tissue and increases greatly in those parts characterized by mature cell walls.

A more critical study of cell walls by Fremy, Mangin, Bertrand and others has shown that these are by no means homogeneous structures, either chemically or structurally speaking, but consist characteristically of an outermost layer lying on the boundary line between adjoining cells and other layers lying between it and the

[13] True, Rodney H., and Bartlett, Harley Harris, *Am. Journ. Bot.*, 2: 255-278. 1915.

[14] True, Rodney H., and Bartlett, Harley Harris, *Am. Journ. Bot.*, 2: 311-323. 1915.

[15] True, Rodney H., and Bartlett, Harley Harris, *Am. Journ. Bot.*, 3: 47-57. 1916.

plasma membranes. This outermost boundary layer consists of a calcium salt of a weak organic acid known since work of Mangin as pectic acid. Not only is this structure Ca pectate, but in cases other layers of similar chemical character occur in the thickening materials laid down in the more interior parts of the wall. This Ca pectate has been shown to be a stiff adhesive colloid that is formed when pectic acid meets Ca ions. According to authors from Fremy to Bertrand this acid appears when the neutral mother substance pectin is acted on by the enzyme pectase.

Now in view of the observations of Mangin, Bertrand, and others, and latterly those of Sampson [16] there seems to be considerable freedom in the shifting of cell wall materials into and out of the pectic acid condition, and when Ca ions are present, with the consequent appearance of calcium pectate layers. These chemical shifts are frequently explicable only by relaying them back to internal irritable causes. They appear then in cases to be self-regulated chemical responses to stimuli, perhaps due in the first instance to external conditions, but in their immediate application, to internal causes. Thus Sampson finds in the abscission tissue of coleus leaves following the shock due to inflicted injury a change of more or less of the cellulose of cell wall tissues to pectic acid with a disappearance of calcium ions from the cells of the abscission layers and from their walls. Sampson favors the view that the change of cellulose into pectic acid arising from the irritation that sets in motion the train of abscission phenomena is responsible for the disappearance of Ca. Pectic acid being present greatly in excess of the quantity of Ca ions present can not be converted by these ions into the firm colloid, calcium pectate, but creates a thin, mechanically weak colloidal medium which mutually interdiffuses with the Ca ions and in proportion as the pectic acid exceeds the Ca dilutes and removes it from its original seat.

In this connection it should be noted as a general observation that the conversion of cellulose into pectose is a usual feature in aging cell walls (Sampson: 48). The shift from pectose to pectic acid follows easily.

The change in firmness of fruits and vegetables seen to follow the action of parasitic or of saprophytic fungi seems to be a related phenomenon. Here some form of Wiesner's theory of the generation of organic acids which take possession of the Ca tied up in health in the Ca pectate layers seems likely to apply. With the removal of the Ca by acids formed directly or indirectly by fungi, the pectate layers become pectic acid or something closely akin. Since these substances lack mechanical strength, a slump of the tissues follows.

It was my good fortune to be able during the winter of 1919-20 to associate Dr. Sophia H. Eckerson of the University of Chicago with our work on this calcium problem, then being carried on in the U. S. Department of Agriculture and with her permission I beg to refer here to some of her findings. She grew seedlings of wheat, maize and white lupine in series of solutions closely paralleling others that were receiving attention, or had received attention in conductivity experiments. Dr. Eckerson applied the methods of microchemistry to the study of seedlings grown in potassium solutions in which Bartlett and the author had found a leaching of ions from the seedlings into the solution. She observed (1) that ions readily entered the cells of the roots, (2) that within twenty-four hours Ca ions began to diffuse out of the calcium pectate middle lamella, (3) *K* pectate was formed instead of the Ca salt and this substance being relatively soluble in water soon dissolved, (4) at this stage, *sugars, amino-acids,* and *salts,* chiefly Mg, diffused rapidly out of the roots. Thus we find Dr. Eckerson's microchemical evidence giving us the stages of an event already found to exist by means of our grosser conductivity work. It was established beyond doubt that not only was the cell wall modified and in part dissolved by the replacement of Ca ions by K ions in the solution, but it was shown that the damage goes far more deeply into the cell. Analyses of the leach into distilled water by lupine roots has already demonstrated to us that no less than two thirds of

[16] Sampson, Homer C., *Bot Gaz.*, 66: 32-53. 1918.

the materials yielded were organic and perhaps in large part non-electrolytes. Dr. Eckerson finds that the leach into K solutions are largely organic and non-electrolytic. These solutions must have come in considerable part from the cell contents. The permeability of the cell walls had been greatly modified, also the osmotic properties of the plasma membranes.

These modifications were seen in the passing of materials from within outward. Dr. Eckerson tested the permeability in the opposite direction. Corn seedlings after five days in a KNO_3 solution were placed in a 1 per cent solution of copper sulphate. In one hour the Cu ions had penetrated all of the root tissue. Similar seedlings after five days in a $Ca(NO_3)_2$ solution showed the penetration of Cu ions only after twenty-four hours in a similar copper solution. This seems to make it clear that permeability for ingoing ions is also greatly increased by the changes that we have described.

Experimental work on Mg solutions showed that Mg pectate replaced Ca pectate in solutions of Mg salts. It is known that while Mg pectate is not soluble like K pectate and is less permeable it is slightly more permeable than the firmer Ca pectate.

Dr. Eckerson found in addition to this that the fatal result repeatedly seen in our other work to come after a longer or shorter time to seedlings grown in Mg solutions of more than minimal concentration did not occur until the Ca of the middle lamella had been wholly replaced by Mg. When this had come to pass the cells died. We could perhaps imagine that sufficient uncaptured Mg ions were then free to penetrate the deeper structures of the cell to bring about the fatal upset.

The conclusion seems well founded that the integrity of the calcium pectate forming the middle lamella was maintained when a sufficient quantity of Ca ions was present in the culture solution and with it the normal retention of its contents by the cell. When according to the laws of mass action this quantity of Ca ions fell below the equilibrium concentration, other kations present replaced the Ca in the colloid compound forming the middle lamella. As a result of a long series of experiments in various culture solutions, it may be said that no kation other than Ca has been found that can replace it in this relation without an injurious or fatal change seen in permeability relations, or without the appearance sooner or later of other toxic response. Mg comes most nearly to replacing Ca, but fails, partly because of the greater permeability of its pectate, chiefly because of the ultimately toxic action of the Mg ions when they reach the deeper lying structures.

In view of what has been said, what are we justified in thinking concerning the phenomena that lie deeper than cell walls, what about the living content of the cell? I think we are justified in regarding the cell wall and the plasmal membranes that secrete it, and in closest contact with which it lies, as standing in the closest relation. Cell walls, except in specialized locations, are seldom decisive in determining what ions pass through them. They influence, as we have seen, up to a certain quantity the ions that pass into them, through the chemical changes which take place in the walls themselves and thus far may be regarded as having a certain quasi-determining influence. Beyond that, after chemical demands in the walls have been satisfied, more deeply lying equilibria are concerned. As an ion-containing structure, the cell wall maintains ion-equilibria subject to the laws of equilibria in colloids, with the living membranes with which it stands in most intimate chemical and biological contact. When ion equilibria in the wall are disturbed, this disturbance is transmitted to the equilibria of the protoplast that lays it down, modifies it and remains in closest relation to it. Hence it is not surprising that a drastic change in the very chemical composition of parts of the wall itself if continued should work through and perhaps profoundly affect the equilibria of the protoplasm.

This close relation of protoplasm and cell wall has already been seen in the cases of wall change initiated from within in response to irritation. When cells are melted apart by self-regulatory processes it seems hardly necessary to argue the intimate relation of wall change to protoplasm change. In response to

the formative laws governing the organism a dozen or more layers of cells surrounding the embryo of the wheat or maize are completely absorbed and in the end the innermost remaining walls of the ovary are literally cemented to the outer unabsorbed layer of the inner integument.[17] Here is emphatic control of cell walls by the life inhabiting them, control exerted chiefly through the agency of the Ca-ion-equilibria of the tissues concerned. Finally this control in the wheat as in Herbst's sea urchin embryos is shown by the fusing together of *outer surfaces of cell walls.* Here we seem to have clean cut instances to show how in the formative processes the living material is able to command the structure it forms about itself. The outer walls of cells originally located far from each other are brought together by the solution of intervening structures. The substances necessary for the formation of the cementing layer seem to be extruded from the protoplasm through the wall to the outside surfaces where they unite to form the coagulum seen. Perhaps the Ca ions and the pectase thrust through from the interior of the cell meet at its frontier the pectin which under enzyme action yields pectic acid in the presence of the Ca ions. The product of such an occurrence would be seen in the cementing layer formed on the outside of each of the now neighboring cells.

In conclusion, I should like to refer briefly to some of the more practical results that seem to flow from the considerations that have been here set forth.

It appears that a certain quantity of Ca ions must be present in the medium for the maintenance of the chemical and functional integrity of the cell wall, as well as the chemical and functional integrity of the deeper lying living parts of the cells of absorbing roots of higher green plants. When this is so maintained, absorption takes place in the manner we are accustomed to call normal. When this necessary minimal supply of Ca ions in the medium is lacking, be it in soil solution, water culture, or sand culture, the function of absorption is upset and a more or less marked leaching of ions from the plant follows. In the absence of this necessary minimum of Ca ions, the soil solution or culture solution may be rich in all other required ions, but these are useless to the plant. They are unabsorbable. This brings us face to face with a condition of affairs in plant nutrition that has not been recognized and therefore has not been characterized. We may fairly say that Ca ions make *physiologically available* other equally indispensable nutrient ions. The practical consequences that follow from this way of looking at the fertilizer problem have not thus far been realized. We learn why from earliest times civilizations have grown up on soils rich in limestone dèbris. We learn why agriculture has readily succeeded in some regions, not in others. We understand why, by the use of lime, lands have been rendered capable of supporting largely increased populations. We are now able to correlate these broad facts with those of cell physiology and to suggest perhaps not *the calcium function* sought by Jost, but one way perhaps of many in which higher green plants find calcium necessary.

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[17] True, R. H., *Bot Gaz.*, 18: 212-226. 1983.

THE METHOD OF SCIENCE IN AGRICULTURE[1]

To be practical has been the great goal of agricultural investigation from the beginning. It was entered upon with a practical purpose, and in a large degree practical results early came to the expectation of the farming people. Here was a type of science which was not working in the clouds for its own sake, but down in the dirt where the problems of farming lay.

It is fortunate that this has been so—that this close sympathy and this urge to meet the needs of the art have been felt so keenly. It has given life as well as purpose to our branch of science, and the wide extent to which its

[1] Address of the Vice-president and Chairman of Section O—Agriculture, American Association for the Advancement of Science, Toronto, 1921.

findings have been embraced and woven into the warp and woof of intelligent practice has been a constant source of stimulation. It makes even more imperative the call for steady progress, not only in getting practical results for immediate use, but in securing deeper insight and larger intelligence about the common things of agriculture.

The problems of agricultural science have become increasingly difficult. As the simpler things lying near the surface are gradually solved the underlying problems are seen to be more complex and difficult, taxing knowledge, skill, and imagination to increasing extent. Almost have they come to call for that rare perspicacity of the colored preacher who claimed to be able "to explain the unexplainable, to make known the unknowable, and to unscrew the inscrutable."

At all events, there is no more exacting field of experimental inquiry at the present time, and success in it is largely a matter of methods. It calls for a clear conception of the nature of problems and means for deriving the needed data for their solution. Steady advancement in some of the oldest and most common lines of agricultural inquiry rests more largely on the development of methods than on additional experiments or the accumulation of data on the conventional basis. It is the largest problem in agricultural investigation at the present time, and it is so important that in a large degree it determines the progress of science.

Fundamentally the method of science is the same, of course, in agriculture as in the simple sciences. It makes no difference whether the subject is cornmeal or a chemical compound, the response of the growing plant or the law of falling bodies, the experimental method and requirements for the same grade of inquiry are the same. But in practice different types of effort are represented which vary with respect to their aim and the extent to which they require application of the scientific method. The difference is perhaps chiefly a quantitative one, of degree rather than kind, in conception of the end of inquiry rather than in general essentials which must be met.

In the simpler form of agricultural work, consisting of observations, tests and trials, the object may be a quite superficial one—the attempt merely to get a bit of information but one step removed from ordinary experience, such as the profit from use of a fertilizer, the larger crop from spraying, or the advantage of fall plowing. The information may be quite sufficient for the practical purposes of the time and place, but it can not be said to be very scientific, even if made with every care, for the work involves no study of exact relationships or tracing of the effect of conditions. In other cases observations, tests and trials may have a deeper purpose and form a step in investigation. Similarly, experiments may be purely comparative, as showing the relative value of different fertilizers, or feeding stuffs or methods of tillage, without touching any basic fact; or they may be the means of securing scientific facts in a piece of fundamental research.

In the early stages of agricultural experimentation, before the problems had been organized to show their nature and content, the work was naturally elementary, based largely on observations, comparative trials, and simple experiments which did not attempt to determine the underlying conditions or establish definite relationships. These types of work have given results which although largely empirical have been extremely useful. They have supplied a great fund of information on which to develop practical systems and to base further experimental inquiry. Although sufficient for one stage, they may be a poor means of progress in another. Hence they need to be replaced by more rigorous methods and by investigation which goes to the heart of the problems.

It has been a somewhat prevalent mistake to assume that a complex agricultural problem could be solved in its practical aspects without a study of the principles and factors underlying it. This has led to the attempt to secure quick results by short cuts, and has bred overconfidence in the competence of simple comparative experiments. Reliance upon such time-honored procedure in certain classes of work has re-

sulted in the effort to refine them without going outside of them or bringing to their support more abstract types of inquiry which the changing status of the problems made necessary.

This is not to overlook or to minimize in the least the increasing extent to which agricultural research has advanced into new fields or stages of inquiry, has developed improved methods and means of progress, and has been rewarded with results comparable with those in any line of investigation. Such effort has well illustrated the truth that in this branch of research as in other walks of life "we build the ladder by which we rise"; and it argues for a type of experimental work which is critical of its methods and conclusions, seeking means for strengthening them and avoiding error or uncertainty. But certain types of work have not been marked by such growth of vision and method, with the result that they have become doubtful means of scientific progress at the present time. They continue to perpetuate their possible errors or inherent limitations after these have been disclosed. They are not fulfilling the expectations originally placed upon them; and while they have been useful up to a certain point, they are accumulating data after they have ceased to shed new light.

The aim of science is simplicity, the dissolution of complexities, and development of simple facts and statements easily comprehended. Its method begins with a simplifying process, the analysis of problems to get at their real nature and content, the resolution of complex questions into parts which are sufficiently simple and self-contained to be capable of study. Often this can be only partially done at the outset, but as the investigation proceeds and the real nature of the problem is disclosed, the segregating process becomes easier.

In agricultural investigation this is difficult because of the many factors embraced, and in the more common types of work with plants and animals it has been followed to only a limited extent. More often the problem has been an involved and complex one from the start, embracing a wide range of phenomena, and instead of being simplified and reduced to smaller definite units as the work progressed, it has gathered bulk as it went, like a snow ball, until it has become such a complicated aggregation as to be well-nigh unworkable. Too large for any intimate study, the mechanics and routine of it have occupied the full time, and it has often degenerated into the broad accumulation of data.

In constructive research data are secured for use, not for themselves. They are designed for a definite purpose—to solve a concrete problem, to prove or disprove a conception or an idea, to disclose scientific facts. The undirected collection of facts, whether they be observations, results of experiments, or what not, leads to complexity, to an aggregation of data which must first be classified before being used in molding a scientific explanation or a principle, or developing even practical information. Unless there is a clear objective and an idea to guide in the acquiring of data, it may be a waste of time, an aimless, hopeless, dead effort. Its results may be chaotic, impossible of developing a leading principle or an illuminating fact.

There is still a quite prevalent idea that the ends of research may be satisfied by the accumulation of data. It is a common expression in connection with the status of long-continued experiments that data are being accumulated. This is especially apt to be the case where such complex conditions and factors are involved that the results from year to year are confusing, and it is assumed that these uncontrolled variables may be eliminated by long repetition. In such cases there is apt to be lack of a critical attitude toward both the method and the data themselves, and hence the test of adequacy or competence is not applied. Data add to the accumulated fund of information when they are accurate, systematic and orderly, and so capable of enabling deductions or fitting into other supplies which may be so used. Unless they respond to such a test it may well be questioned whether their accumulation is profitable at this stage, when there is already such a large background.

Simplification and definiteness of purpose give direction to the making of records and the gathering of data. All experimental inquiry turns upon securing proof which is both accurate and adequate to the purpose. The method of science is the process of securing accuracy and precision in purposeful observation, and the interpretation of the product. As has been said, it is "only a perfected application of our human resources of observation and reflection."

The method is not a fixed thing but is continually changing as progress makes possible. Science strives constantly after new ways of acquiring and proving facts which would otherwise not be known or but imperfectly so, and at the same time eliminating the personal factor. Apparatus and appliances are designed primarily to make possible the taking of observations which would otherwise not be feasible, or with equal accuracy. They therefore enlarge the field of observation and increase precision.

This applies of course to facilities and methods for agricultural inquiry such as field plats and cylinders, feeding appliances, special apparatus and other means for securing experimental data; and there is the same need of critical examination of these from time to time that there is of other facilities, to determine whether they are supplying proof which is accurate and sufficient, or to assess correctly what can and what can not be shown by such methods.

The question is forcing itself upon the minds of many as to the adequacy of certain types of field experiments, as ordinarily conducted, to answer fundamental questions in plant nutrition and soil management. Large reliance has been placed on such experiments in the past, and data have been accumulated from them over long periods. The oldest series of fertilizer and rotation plats in this country runs back over forty years; several others have been under way from twenty-five to thirty-five years. One station has some two thousand plats.

These experiments have brought highly important practical results, and have marked a definite step in agricultural inquiry. They have furnished a rich background of material and suggestion for more definitely directed studies. The question is whether they have reached their maximum and how far they are to be depended upon in making further advances.

It is now realized that many of these experiments contain inherent difficulties dating back to their beginning, which introduce a strong element of doubt in interpreting results. For one thing, most of the published reports fail to describe the soil except in the most general way, and lack information as to the condition and previous treatment of the field, indications of irregularity, etc. Again, the number of check plats is usually too small, and the same is true of the amount of replication of treatment. This may account for the different interpretations made by different persons from the same series of experiments. In few cases has the necessary number of checks and duplicates been worked out mathematically for such experiments, and where there is considerable variation in different parts of a field, averages may furnish a doubtful basis for measuring the effect of treatments.

The number of questions "put to the soil and the plant" in a given plat experiment has usually been far too large. For example, the customary rotation-fertilizer experiment has often covered practically the whole range of soil fertility and plant nutrition. This wide range has limited the amount of replication practicable, and it has failed to reflect the discrimination in gathering data and the simplification of the problem dictated by the method of science.

Such experiments have relied quite largely on what the field results themselves were interpreted to show, primarily the crop returns. True, most of the later experiments have embodied plans for chemical, bacteriological, and other laboratory studies, but only to a limited extent have these been developed with the progress of the work so as to shed new light. The chemical studies have often become of a routine nature—analyses of the crops and of the soils at stated intervals, and the bacteriological studies by the technique developed

have largely failed to meet expectations in establishing correlations between soil treatment and bacterial flora. Such bacteriological observations have now almost ceased in connection with long continued field experiments.

Reduced to such a simple collection of experimental data, the conduct of these extensive field experiments has often become largely a matter of routine. The niceties of plat work are observed, but the element of actual inquiry is deferred until many years have supplied their data. When that time is reached the publication is more often a summary of field and and laboratory records than a critical analysis of the data and their actual meaning. At best the product is quite apt to consist of empirical observations rather than definite contributions to fundamental principles. We have not yet learned how to interpret, except superficially, the answer which the soil and the plant give as to just what has happened or what the apparent effects are due to. We have not yet learned how to examine a plot of soil so as to determine the changes occurring from time to time or brought about by a long continued system of treatment, or how to connect these changes with the response of the crop in a given season or period. Indeed, relatively little study is now given in such experiments to the soil itself, and only to a limited extent are underlying questions suggested by such experiments being given intensive study.

In a word, the indications are that in the majority of cases the use is not being made of such long-time field experiments that ought to be made at this stage. They are rarely being simplified as time goes on, with a narrowing down to specific problems for intensive research, and they are not being increasingly supplemented by definitely directed laboratory study. They ought themselves to be progressive both in method and outlook. They ought to be used as the source of problems and material with which to make further and more profound inquiries.

We can hardly fail to recognize the changed status at the present time, both as to practical requirements and the stage which has been reached in research and its problems. What is especially needed at this stage is the study of factors and their relationships rather than gross comparisons of one complex of conditions with other complexes. This will call for the kind of team work which has been applied to the Rothamsted experiments,—the association of the chemist and the bacteriologist with the agronomist and soil expert, and the guidance of the statistician in both planning and interpretation.

In many of the feeding experiments, also, the unchecked sources of possible error are too great for safety. The small number of animals in the lots gives large chances for the influence of individual variation. The conditions and frequency of weighing may also give misleading indications. Some of the results of such experiments can be measured quite accurately, while others can only be described. Some are not strictly experimental because they embody so many factors not under experimental control and whose probable variation can not be estimated. This is true, as Dr. H. H. Mitchell has recently shown, of the cost or financial returns in feeding. Such results lack permanent value, and are likely to be given a prominence and an application which they are not entitled to.

Experiments of this practical type have been useful in the past and there will be need for them in future. It is important that they occupy their proper place; but in the scheme for investigation they should not take the place of nutrition studies based on more permanent factors than prices and food combinations, or reliance rest too largely on them at this stage.

Many important advancements have been made in animal nutrition which will find application in feeding practice and in showing the reason back of it. These disclose more clearly the functions to be discharged by food, the inherent qualities which account for the observed value or special properties of feeds, and the means of measuring the response of the animal with a high degree of accuracy. Such fundamental investigations ought assuredly to be encouraged, not to the exclusion of but along with the type of feeding experiments which seek a more immediately practical end.

There is still need to cultivate intelligent public appreciation of research conducted in accordance with the spirit and the method of

science. It has been far easier to get funds for types of work which promise early contributions to practice than those which dig deep and lay solid foundations to make the whole superstructure sure. The dependence of the former upon the latter needs to be recognized.

The magnificent work of Armsby and his associates has been the admiration of the scientific world, but in spite of its ultimate practical value, and especially in furthering investigation, it had not within itself the elements of publicity, and was only vaguely understood. It never had an assured permanent income, and in that sense was obliged to live from hand to mouth. The loss this entailed is realized too late; and now the future of the work he so admirably started is under discussion. It would be a calamity if it were allowed to fall to the ground.

The large amount of attention now being given to fundamental and searching inquiry on the soil, the conditions of plant growth, and related subjects, should not fail of mention in this connection, for it illustrates the development of insight into these problems. At no period has there been anything comparable to it. The results which are following from these intensive studies amply justify the expectations of them as constructive means of progress.

With all the facts clearly in mind, it is very important to take an account of stock in the more conventional lines of experiment; to study seriously the long list of the better experiments in order to determine what they have actually shown, what they are competent to show, and the lessons they teach in methods. By all means, let us garner in all the teachings of these field and other common types of experiment; let us profit by both the good and the bad experience, but let not the negative results be overlooked in searching for the more positive ones. Such experiments represent large annual expenditures, and they occupy the time of a large body of workers. They express a confidence on which men are staking their efforts and their prospects. It is important to know the place which such experiments should occupy in future study and the manner in which they need to be supplemented. This may be one of the fundamental lessons to be drawn from them, and may indicate that their most useful field is in supplementing laboratory studies, rather than the reverse as at present.

In a public supported enterprise like agricultural investigation there must necessarily be a happy combination of effort representing different grades of intensity. Some problems or stages of them call more urgently for the full measure of the method of science than others, and it will be for the investigator to govern himself accordingly. But he can not fail to exercise a critical attitude toward all his work and his methods, or to exemplify in them the element of real progress.

E. W. ALLEN
U. S. DEPARTMENT OF AGRICULTURE

THE CONCILIUM BIBLIOGRAPHICUM

IN the issue of *Science* of December 2, I called attention to the critical situation in which I found the Concilium Bibliographicum this summer, when I made a special trip to Zurich to investigate this situation for the National Research Council and the Rockefeller Foundation.

On the occasion of this visit I proposed, after conferences with Mrs. Field (widow of the late Dr. H. H. Field), her business advisers, the chief of the technical staff of the Concilium, and official representatives of the Swiss Natural Science Association, which becomes under Dr. Field's will the legatee, under certain conditions, of Dr. Field's financial interests in the Concilium, a plan for an immediate temporary reorganization of the Concilium to last until January 1, 1922, and a further plan for a provisional permanent reorganization to go into effect as from that date.

The plan for temporary reorganization was put into effect immediately with Professor J. Strohl, of the Zoological Institute of the University of Zurich, as acting director, without salary. The proposed provisional permanent reorganization—by "provisional permanent" I mean a well considered and fully supported organization to run on until international mat-

ters may indicate a desirable change—required, for putting into effect, the approval and definite action of the Field estate, the Swiss Natural Science Association, the National Research Council, and the Rockefeller Foundation. I obtained the formal agreement of the Field estate and Swiss Association before leaving Zurich and now the Research Council and the Rockefeller Foundation have signified formal approval and taken the necessary definite action.

This arrangement, which would require too much space to set out in detail here, provides for the control of the Concilium, until some later arrangement for control by a satisfactory international board can be made, by a special Commission set up by the Swiss Natural Science Association on which there shall be an official representative of the National Research Council whose acquiescence must be obtained for any major activity or expenditure of funds proposed by the commission. In addition, the National Research Council sets up a special committee on Concilium matters to advise and instruct the Council representative on the Swiss Commission. This committee of the Research Council is composed of Drs. R. M. Yerkes and L. R. Jones, and myself as chairman. I am also appointed as the Council's representative on the Swiss Commission.

To clear up the current obligations of the Concilium and help maintain it during the next five years the Rockefeller Foundation has appriated and pledged to the National Research Council the following sums: Appropriated: to meet outstanding obligations, $15,000, and for maintenance during 1922, $20,000; pledged: for maintenance during 1923, $20,000; during 1924, $15,000; 1925, $10,000; 1926, $5,000, after which the Foundation assumes no further financial obligation for the Concilium. This means that the Concilium must arrive at a self-sustaining condition by January 1, 1927, or have found by then other philanthropic assistance.

It is proposed that a staff composed of a director, a competent secretary-bookkeeper, three trained technical assistants, three untrained assistants, and the needed stenographers and messengers, be arranged for at once. To maintain this staff and provide the necessary office expenses (postage, telegraph, telephone, fuel, lighting, etc.) the Concilium has not only the Rockefeller Foundation subvention but an annual subsidy of 5,000 francs (Swiss) a year from the Swiss Government and one of 1,000 francs (Swiss) from the Canton of Zurich. It has also whatever income can be derived from sale of its bibliographic cards and books. It has a building of its own, well suited and fairly well equipped for its work.

Thus the Concilium has, thanks to the generous action of the Rockefeller Foundation, a new lease of life and Dr. Field's noble and self-sacrificing work and his plans for increasing the Concilium's usefulness are not to go unregarded. Plans for extending the bibliographic work to other fields not now covered by it, and for a possible development of an abstracting system in addition to the present subject, title and author references, are under consideration. In this connection the managing board of the Concilium will need and will welcome all the advice that can be given it.

There should be, also, a greatly increased list of subscribers to the cards and books issued by the Concilium. The National Research Council will undertake a campaign to add to the list of American subscribers, and the Director (in Zurich) will institute a similar campaign in Europe. So I shall have occasion to ask the editor of *Science* for space in the near future for still another note about the Concilium.

VERNON KELLOGG
THE NATIONAL RESEARCH COUNCIL

HENRY TURNER EDDY

THE death of Henry Turner Eddy occurred at his home in Minneapolis on December 11, 1921, due to an acute attack of pneumonia, after only a few days' illness.

Dr. Eddy was born at Stoughton, Mass., on June 9, 1844. He was the son of Henry Eddy,

Yale '32, Congregational minister, and Sarah Hayward (Torrey) Eddy, a graduate and teacher of mathematics at Mt. Holyoke Seminary.

Dr. Eddy graduated from Yale A.B. '67, Ph.B. '68, A.M. '70, Hon. Sc.D. 1912; Cornell, C.E. '70, Ph.D. '72; and Centre College (Ky.) LL.D. He also studied at the University of Berlin and at the Sorbonne, Paris. He was instructor in Latin and mathematics at the University of Tennessee, 1868-9; assistant professor of mathematics and civil engineering, Cornell, 1869-73; adjutor professor mathematics, Princeton, 1873-4; professor of mathematics and astronomy and civil engineering, 1874-90, and dean of the academic faculty, 1874-7, at the University of Cincinnati, and was its president-elect in 1890. The following year he went to Rose Polytechnic Institute, Terre Haute, Indiana, as its president and remained there until 1894, when he resigned and went to the University of Minnesota as professor of engineering and mechanics, in the College of Engineering. In 1906 he was elected dean of the Graduate School, which position he held until his retirement from university work in 1912 as professor and dean emeritus.

After his retirement from teaching at 68 years of age, Dr. Eddy formed an association with Mr. C. A. P. Turner, consulting engineer, of Minneapolis, and spent several happy years in mathematical researches concerning the properties and stresses in reinforced concrete floor slabs, the results of which he published in collaboration with Mr. Turner. Dr. Eddy was one of the first to take up the subject of graphical statics and in 1878 he published his well-known "Researches in Graphical Statics"; this was followed in 1879 by a treatise on "Thermodynamics"; previously to this he had published a mathematical text on "Analytical Geometry."

Dr. Eddy was a member of numerous scientific societies of varied interest, including the American Association for the Advancement of Science, of which he was one of the vice-presidents in 1884; the American Philosophical Society, the American Mathematical Society, the American Physical Society, and the Society for the Promotion of Engineering Education, of which he was an honored past president. He was a man of versatile attainments, as shown by his many valuable contributions to the various societies to which he belonged.

Dr. Eddy was a man of quiet, scholarly tastes, genial in his intercourse and always an inspiration to his associates. He was married in 1870 to Sebella Elizabeth Taylor, of New Haven, Conn., who died on September 5, 1921, only three months prior to the death of her husband. The surviving children are: Horace T. Eddy, Omaha; Mrs. Charles F. Keyes, Minneapolis; Mrs. Clive Hastings, Atchison, Kan.; Mrs. Charles H. Patek, Minneapolis, and Mrs. J. B. Frear, Buffalo, N. Y.

The faculty of the Graduate School of the University of Minnesota has placed on its records the following tribute:

Henry Turner Eddy, Ph.D., LL.D., died on December 11, 1921, at the age of 77 years. In his death the faculty of the University has lost one of its most eminent and honored members.

As professor of mathematics and mechanics from 1894 to 1905, as the first dean of the Graduate School from 1906 to 1912, and as professor emeritus since 1912, Dr. Eddy was a distinguished associate whom the faculty was proud to own as a colleague. His ability as a mathematician won him an international reputation and his high general scholarship and Christian character endeared him to all with whom he came in contact. He was an educator of the highest type, an inspiration to his students and intimate associates, and a wise, sympathetic counsellor in the faculty conferences.

This faculty would express its heartfelt sympathy with the family, in the faith that God has given the departed a rich reward; and the assurance that it cherishes the memory of a noble life that has left a precious and imperishable heritage.

J. J. F.

SCIENTIFIC EVENTS

THE STERLING HALL OF MEDICINE OF YALE UNIVERSITY

THE Yale Corporation and the Sterling Trustees will appropriate from the Sterling funds the amount of $1,320,000 for the erection of a new and modern building to be known as the Sterling Hall of Medicine. With this

purpose in view the university has recently acquired most of the city block bounded by Cedar, Broad, Palmer and Rose streets where the dispensary now stands, opposite the New Haven Hospital.

The Sterling Hall of Medicine will have a central entrance and building at the corner of Broad and Cedar streets containing a library of approximately 12,000 volumes, an amphitheater with a seating capacity of about 250, the administrative offices of the dean and registrar, a room for faculty use, students' common room, and on the third and fourth floors single rooms and suites for unmarried instructors in the pre-clinical subjects. Extending along Broad street a wing will provide space and laboratories on the first and second floors for the department of physical physiology, with like provision on the third and fourth floors for the department of pharmacology and toxicology. A similar wing facing the Brady Laboratory and the administration building of the New Haven Hospital on Cedar street will provide on the first and second floors space for the department of chemical physiology, the two upper floors being given over to laboratory space for anatomy. Beyond the central structure will be an animal house where various types of domestic animals will be kept for experimentation and observation, these being available for all departments of the university located in the vicinity of the hospital. The power house, designed on the unit basis with stack and bunkers of sufficient capacity for future requirements of the hospital and the school, will be situated at the corner opposite to the central building.

Day & Klauder, of Philadelphia, are the architects of the Sterling Hall of Medicine. One of the features of this building will be the provision for future expansion as the needs of the School of Medicine require and its finances permit. This means the ultimate completion of the quadrangle.

One of the features of the expansion of the Yale School of Medicine has been its closer affiliation with the New Haven Hospital and the Dispensary. In addition the finances of the hospital have been placed on a stronger footing and the physical rehabilitation has been begun.

Placing the faculty of the Medical School on a university basis of full time organization in the clinical service has been an important step in the consolidation of the work of the Medical School and the New Haven Hospital. With the beginning of the fall term of the present year all four of the clinical departments of the School of Medicine have been placed on such a basis.

THE CROP PROTECTION INSTITUTE

The first annual meeting of the Crop Protection Institute will be held at Rochester, N. Y., in connection with the New York Horticultural Society's meeting. A dinner will be provided on January 12 at the Rochester Chamber of Commerce.

Among those taking part on the program will be Professor W. C. O'Kane of the New Hampshire Agricultural Experiment Station, and chairman of the board of governors of the Crop Protection Institute, who will speak on the ideals of the institute; Dr. L. R. Jones, chairman of the Division of Biology and Agriculture of the National Research Council, whose theme will be the "Relation of Environment to Disease and Disease Resistance of Plants"; Dr. R. W. Thatcher, director of the New York Agricultural Experiment Station, who will speak informally on the "Need for Investigations in the Chemistry of Insecticides and Fungicides." From the standpoint of industry, Mr. G. R. Cushman, of the General Chemical Company, will speak briefly. Professor P. J. Parrott, of the New York Agricultural Experiment Station, will also probably speak on "Paradichlorobenzene."

The Crop Protection Institute, which has a membership of about three hundred and fifty prominent entomologists, plant pathologists, agricultural chemists and manufacturers of insecticides and fungicides and others interested in the protection of all kinds of crops, was organized only a year ago, under the auspices of the National Research Council of Washington, D. C. The purpose of the institute is not to duplicate the work of individuals or other organizations, but to bring about closer cooperation of effort, to strengthen the weak places and develop needed investigations that are not being pursued by other agencies.

Those interested, though not members, are invited to attend.

PUBLIC HEALTH WORK IN THE PHILIPPINES

The Rockefeller Foundation announces that the International Health Board has accepted an invitation to cooperate in carrying out the general scheme of reorganization of the public health activities of the Philippine Islands, which was recently made public by the president of the Senate, Manuel Queson.

The participation of the board will consist in lending the services of certain members of its staff for a limited period and providing specialists as consultants and assists to Philippine government officials in various lines of public-health work. The broad program which the government has adopted for improving health conditions includes the ultimate consolidation of all health functions in a single department of health to correspond with the ministry of health in other countries.

Among the persons whose services will be furnished by the Rockefeller Foundation is an assistant to the dean of the College of Medicine and Surgery of the University of the Philippines, who will assist in developing the medical school and will give particular attention to the problem of providing post-graduate instruction in public health, so that the health workers so urgently needed in the Philippine Islands may be trained locally.

Fellowships for advanced study in the United States will be offered by the board to exceptionally promising and well-qualified young Filipinos, to fit them for the more important administrative and technical positions in the public-health service and for positions as instructors in the College of Medicine and Surgery and as teachers of nursing. Existing facilities for the training of nurses are said to be inadequate to meet the demand for hospital and private service. The nursing situation will therefore be studied and special attention given to training women in public-health nursing.

An assistant will be provided for the director of the Bureau of Science, who will be expected to advise in the further development of that bureau. The Biological Laboratory, which is one department of the Bureau of Science, is to be expanded in order to serve as the central public-health laboratory of the Philippines, with local laboratories in the provinces.

Dr. Victor G. Heiser, director for the East of the International Health Board, and formerly director of health for the Philippine Islands, who is now in New York, will go to Manila in February to assist in carrying out the program.

SCIENTIFIC NOTES AND NEWS

THE meeting of the American Association for the Advancement of Science and of the associated scientific societies held at Toronto from December 27 to 31 was notable both for the scientific programs and for the admirable arrangements made for the entertainment of members. The total registration was over 1,800, which is about twice the number anticipated. Large audiences were present at the general sessions at which Dr. L. O. Howard gave the address of the retiring president and Professor William Bateson spoke. The University of Toronto conferred its honorary doctorate of science on Professor Bateson, Dr. Howard and Professor E. H. Moore, the president of the association. We hope to publish the permanent secretary's report of the meeting in the next issue of SCIENCE. Officers were elected as follows:

President

J. Playfair McMurrich, professor of anatomy in the University of Toronto.

Vice-presidents and Chairmen of the Sections

Section A (Mathematics): G. A. Miller, University of Illinois.

Section B (Physics): Frederick A. Saunders, Harvard University.

Section C (Chemistry): W. Lash Miller, University of Toronto.

Section E (Geology and Geography): Charles P. Berkey, Columbia University.

Section F (Zoological Sciences): Maynard M. Metcalf, Oberlin College.

Section G (Botany): Francis E. Lloyd, McGill University.

Section I (Psychology): Raymond Dodge, Wesleyan University.

Section K (Social and Economic Sciences): Henry S. Graves, Washington, D. C.

Section L (Historical and Philological Sciences): William A. Locy, Northwestern University.
Section M (Engineering): George F. Sivain, Harvard University.
Section N (Medical Sciences): Francis W. Peabody, Harvard Medical School.
Section O (Agriculture): R. W. Thatcher, University of Minnesota.

Professor W. M. Wheeler, of the Bussey Institution, Harvard University, was elected president of the American Society of Naturalists at its meeting held last week at Toronto.

Professor Henry B. Ward, of the University of Illinois, who for twenty-seven years has been secretary of the Society of Sigma Xi, and has been in large measure responsible for its development during this period, was elected president at the meeting held at Toronto during Christmas week. Professor Edward Ellery, professor of chemistry and dean of the faculty at Union College, was elected to succeed Professor Ward as secretary.

At the meeting of the Geological Society of America and the affiliated societies held last week at Amherst, a silver loving cup was presented to Professor B. K. Emerson, who became head of the department of geology at Amherst College in 1870. The presentation was made by Dr. John M. Clarke, whose address we hope to print.

Dr. W. W. Keen, of Philadelphia, has been elected a foreign associate of the French Academy of Medicine.

Dr. C. Lloyd Morgan, D.Sc., F.R.S., late principal and emeritus professor of the University of Bristol, was presented on December 2 with his portrait, a gift from friends, colleagues and students, both past and present. The portrait was painted by Mr. Anning-Bell.

Dr. J. G. Adami, lately professor of pathology in McGill University Medical School and now vice-chancellor of Liverpool University, has been admitted to the freedom of the City of London.

Mr. Alfred D. Flinn, secretary of the United Engineering Society and Engineering Foundation and chairman of the Division of Engineering, National Research Council, gave an address on "Engineering, research and vicarious tests" at the meeting of the American Philosophical Society on January 6.

Dr. Allen K. Krause, associate professor of medicine, Johns Hopkins University, will deliver the fifth Harvey Society Lecture at the New York Academy of Medicine on Saturday evening, January 21. His subject will be "Experimental Studies on Tuberculous Infection."

Dr. Charles Moureu, professor of chemistry at the Collège de France, who is now in this country as technical adviser to the French Mission for Disarmament, delivered an address on "Natural gases, with special reference to the rare gases" at Columbia University on December 20.

An International Society of Medical Hydrology was founded at a meeting of the Royal Society of Medicine on December 9, with a preliminary membership of 71 medical men from 13 countries. Dr. Fortescue Fox was elected president.

The third congress of the International Society of the History of Medicine will be held in London from July 17 to 22 under the presidency of Sir Norman Moore.

Dr. Adolf Lorenz, the Vienna orthopedic surgeon, has been granted a license to practice medicine in the State of New York. The Board of Regents of the University of the State of New York at a recent meeting voted unanimously to indorse the copy of a license issued to Dr. Lorenz in October, 1902, by the Illinois State Board of Health.

On Tuesday afternoons, beginning on January 17, the following lectures will be given before the Royal Institution: Two lectures by Dr. F. H. A. Marshall on "Physiology as applied to agriculture"; three by Professor H. H. Turner on "Variable stars"; five by Sir Arthur Keith on "Anthropological problems of the British Empire," and two by Dr. J. W. Evans on "Earth movements."

We learn from *The Observatory* that the Royal Astronomical Observatory, Arcetri, Florence, Italy, will henceforth devote its

activities to astrophysics, and it will therefore in future be called the Royal Astrophysical Observatory. Professor Antonio Abetti retired from the acting directorship last June on account of age, and has been succeeded by his son, Professor Giorgio Abetti.

ALBERT W. SMITH, formerly dean of Sibley College and recently acting-president of Cornell University, is now consulting engineer with the firm of Henry R. Kent & Co. of New York and Boston.

MORSE B. PRINGLE, chief engineer for the Eastman Kodak Company, has been appointed city manager of Smyrna, Fla.

DR. KARL LANDSTEINER, formerly of Vienna and now of The Hague, has been appointed on the scientific staff of the Rockefeller Institute for Medical Research, New York.

DR. HOWARD S. REED, professor of plant physiology at the Graduate School of Tropical Agriculture and Citrus Experiment Station, University of California, is spending part of his sabbatical year in Mexico, Central America and the West Indies. He will return about March 1.

DR. W. J. HUMPHREYS, professor of meteorological physics, United States Weather Bureau, lectured on "Fogs and Clouds" before the Franklin Institute, Philadelphia, on January 5.

PROFESSOR GEORGE C. WHIPPLE'S book on "Vital Statistics," published in 1919, has been translated into Japanese and is published in Tokyo.

THE American Astronomical Society will hold its next meeting at Yerkes Observatory, Williams Bay, Wis., the week following next Labor Day. The next winter meeting will be held at Vassar College, Poughkeepsie, N. Y., and the summer meeting of 1923 probably at the Mount Wilson Observatory, near Pasadena, Cal.

THE Washington Academy of Sciences has compiled a tentative list of one hundred popular books in science. The list, which was edited by Dr. R. B. Sosman, corresponding secretary, was compiled at the request of Dr. George F. Bowerman, librarian of the Public Library of the District of Columbia. The standard set up for the books is that they must be both readable and scientifically accurate. The subjects covered are anthropology and physiology, heredity, botany, animals, birds and insects, geology, meteorology, minerals, astronomy, chemistry, physics, mathematics and history of science.

The faculty of Mercer University on December 14, 1921, passed the following resolutions:

Resolved, That the Faculty of Mercer University favor the plan of placing the scientific bureaus of the United States government under the jurisdiction of a board of governors, with the view of unifying all governmental science and developing it to the highest possible efficiency, by affording scientific workers permanent tenure of office, greater freedom in investigation, non-interference through politics, and adequate salaries.

Resolved, That a majority, at least, of the said board of governors be appointed by the American Association for the Advancement of Science, in order that the most able executives in the various fields of science may be appointed to such an important governing board, and that its personnel be free from political influences.

WE learn from the *Journal* of the American Medical Association that Senator Wadsworth, of New York, has presented a bill in congress providing for an appropriation of $143,032 to meet the increased cost of land needed adjoining the Walter Reed General Hospital in Washington. On this real estate it is proposed to erect buildings for the medical museum and library and the Army medical school. At the request of Surgeon General Ireland, Congress appropriated two years ago the sum of $350,000 for the purchase of this land, but since the negotiations for the taking over of the property have been under way it has been discovered that it could not be bought at this figure. A request for more money from Congress, therefore, was necessary. Immediate purchase is urged both by Senator Wadsworth, chairman of the Senate committee on military affairs, and Surgeon General Ireland, because it is believed that the land will increase in price in the future and the government should act now as a matter of economy.

The Army medical school is to be the first building erected at a cost of $500,000.

THE returns of the British registrar-general for the quarter ending September, 1921, have been issued. They show that in England and Wales there were 214,850 births, which were 15,017 fewer than in the third quarter of 1920. The rate was 22.5 a year for each thousand of population. The deaths numbered 99,134, and were 9,937 fewer than in the preceding quarter, but 5,441 more than in the third quarter of 1920. The rate was 10.4 per thousand. The infant mortality was 83 per thousand births, being 15 below the average of the ten preceding third quarters.

UNIVERSITY AND EDUCATIONAL NOTES

AN endowment of $110,000 for the department of art as applied to medicine has been given to the Johns Hopkins Medical School. The gift, by an anonymous donor, was transmitted to the trustees through Dr. Thomas S. Cullen. This department has been established since 1911, with Max Brodel at its head, the same anonymous donor having provided funds for its maintenance.

WORK has begun at Pomona College, Claremont, California, on a new chemistry building to cost nearly $250,000. The building will be of reinforced concrete with tile roof and massive tower to conform with the accepted architecture of the college campus. It will provide facilities in undergraduate and research work for 600 students.

DARTMOUTH COLLEGE has received a bequest of $5,000 from the late Judge Ira A. Abbott for the increase of the salaries of professors.

AT a meeting held on December 9, the board of regents of the University of Michigan voted to merge the homeopathic medical school with the medical school of the university. The expense for the maintenance of the homeopathic school was $47,000 last year and there were seven graduates.

DR. GEORGE J. HEUER, associate professor of surgery at the Johns Hopkins Medical School, has accepted the professorship of surgery in the Medical College of the University of Cincinnati. By accepting the post, he will automatically become chief of the surgical service of the Cincinnati General Hospital.

PROFESSOR HENRY JORDAN has recently been made head of the department of electrical engineering at Colorado Agricultural College at Fort Collins.

DISCUSSION AND CORRESPONDENCE

PUBLIC HEALTH AND MEDICAL PRACTICE

THE article "Education in Relation to Public Health and Medical Practice, by Professor S. J. Holmes, which appears in the issue of SCIENCE of November 25, 1921, is a highly interesting presentation of a subject which will merit discussion. Its author, however, falls into the common error of those criticizing another profession than their own, of somewhat overstating the case and taking a too pessimistic view of a situation which is constantly being bettered, as, for instance, when he states that "a large part of the time of well-trained medical men is simply wasted in a kind of desultory practice from which their patients secure no permanent benefit," and that "humanity comes very far short of getting out of the medical profession the aid which it is capable of furnishing." As a matter of fact, there are 106,000,000 persons in this country the vast majority of whom are perfectly well cared for medically. The death rate in our larger cities is constantly falling and there are increasing numbers of organizations devoted exclusively to the study and promulgation of public sanitation which are maintained by physicians who furnish gratuitous time and energy without stint. The laboratory tests which the author enumerates are, for the most part, now taught to every third year medical student and the more elaborate tests of this order are not required by more than four or five per cent. of all patients.

The author further comments upon the ignorance of sanitation among our immigrants (which, of course, is deplorable) and writes that the "uninstructed foreigner" "fails to get competent aid when he is ill."

New York City has admittedly the largest and most varied immigrant population of the country. It has, however, many competent foreign born physicians who care for their own kind, besides many hospitals devoted to the care of special foreign groups, like the Italian, French and Lenox Hill (formerly the German Hospitals, besides several others devoted to Yiddish patients. The Health Board of the city is most active and efficient, together with many other agencies, both public and private, in raising the health standards among the foreign born, and special health lectures are given in different languages in the public schools. The infant mortality of the entire city has never been so low as in the past few years and is a source of amazement to distinguished foreign members of the medical profession who come here. The comments of the author upon the fraudulent medical cults with which the country abounds are well made and nowhere to be better ilustrated than in his own quack-beridden state of California, but it is unfair to shift any of the burden of this upon an assumed negligence of the medical profession, which wages constant warfare against it in its county, state, and national associations, only to be defeated time and again by lay legislators. There are too many other operative factors, notably the sensational press, the general restlessness of the times, and indeed the multiplicity of experimental medical tests themselves, which lead patients to compare experiences with one another and seek all manner of examinations whether they need them or not, in order to get their money's worth out of what the author characterizes as "our commercialized system of private practice"—which remark leads one to wonder whether he knows the average income of the legitimate medical practitioner.

W. GILMAN THOMPSON

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NOTE ON INHERITANCE IN SWINE

THE Berkshire pig is distinguished by the following characters: (1) erect ears, (2) uniform black coat with the exception of "six white points" which occur on the head, on each foot and on the tail, (3) a short "dished" nose, and (4) a somewhat short and broad body. The Large Black pig is distinguished by (1) "flop" ears, (2) uniform black coat without any white, (3) nose not "dished" and of moderate length, and (4) a long body, somewhat narrower than that of the Berkshire. On a farm near Oxford, pure-bred Large Black boars have for some years been crossed with pure-bred Berkshire sows. About a dozen litters have come under the observation of the author of this note and the F^1 generation has invariably shown (1) erect ears, (2) uniform black coat without any white, and (3 & 4) intermediate features as regards nose and shape of body. Latterly, the reciprocal cross has been made (Berkshire boar and Large Black sow) and the F^1 generation shows (1) erect ears and (3 & 4) intermediate characters. But as regards (2) there has appeared a gradation from pure black to spotted pigs in which the whole coat is fairly evenly divided into black and white patches. At present the numbers are small, but it would appear that the gradation is not uniform between the pure black and the spotted condition. There appear to be three classes—pure black, black with the six Berkshire points and spotted. Further it is noticeable that the true spotted pigs have hitherto all been boars, though pure black boars have also appeared.

It may be suggested that erect ear is a simple dominant. The coat color and other features clearly require considerable analysis. It may be that sex linkage is in some way concerned in coloration.

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ON SUMMARIES OF RECENT ADVANCES IN PHYSICS

THE National Research Council has recently issued two valuable pamphlets on the Quantum theory (The Quantum Theory, E. P. Adams, 1920, No. 5; Atomic Structure, David L. Webster, Leigh Page, 1921, No. 14). Similar contributions on other live topics have come, from time to time, from the Bureau of Standards. I wish to express my personal appreciation of

this admirable work and hope that more is in store for us.

We, who are about to be shelved, used to live in this country, peacefully under the constitution and we were quite happy in our simplicity. One day a man by the name of Einstein came along and mixed that constitution up. We were told that it had long been an antiquated document anyway. There were difficulties, but eventually we managed to fit in; for they had left us, at least, with the doctrine of energy. Now, I read that the classical law of the conservation of energy must also go, that at best it is only statistical like the second law of thermodynamics. Truly these young bloods are Balkanizing the whole of physics and our ancient constitution has gone the way of the mark.

Carl Barus

Brown University

SCIENTIFIC BOOKS

Trees of Indiana. By Charles C. Deam, State Forester of Indiana. First revised edition. 317 pages; 137 plates. Publication 13 of the Department of Conservation, State of Indiana. April, 1921.

The forerunner of the present work, under the same title and by the same author, was issued in 1911. So great was the demand for that book that the edition of 10,000 copies lasted only three years, while a second edition, printed in 1919, was exhausted within five days of publication. The present "first revised edition" is fundamentally a new work, with new illustrations and completely rewritten text.

During the past decade numerous "tree books" have been issued by various state organizations, but it is doubtful if any of these contain more original matter than the present work. Certainly none of them contain more local color. The botanical descriptions are based on Indiana material, and the illustrations are photographed from Indiana specimens, while the distributional peculiarities in Indiana of the various species are treated in gratifying detail. It is in this latter particular, perhaps more than any other, that the book will prove of service to the general botanical public. In the course of his studies of the flora of Indiana, the author, within the last ten years, has traveled more than 27,000 miles, by auto, and has visited every county and traversed practically every township in the state. As a result he is able to present, at first hand, a wealth of detail in regard to local tree distribution, not to mention various other observations which bespeak intimate familiarity with the tree flora of the state. The attention given to the ecological relations of the different species is especially worthy of note, and this feature alone will recommend the work to a wide circle of readers.

George E. Nichols

NOTES ON METEOROLOGY AND CLIMATOLOGY

SKY BRIGHTNESS AND DAYLIGHT ILLUMINATION

What is the relation between sky brightness and the electric light load carried by the central lighting plant? How much sky-light will be cut off by a row of buildings on the opposite side of the street These questions and many others may be solved by studies of the brightness of the sky and daylight illumination such as have been carried out by Dr. H. H. Kimball, of the Weather Bureau at Washington. The practical utility of such investigations is attested by the interest shown by illuminating engineers, architects and electrical engineers. A paper, recently appearing in the *Monthly Weather Review*,[1] summarizes with considerable detail a report submitted to the Illuminating Engineering Society, of whose committee on sky brightness Dr. Kimball is chairman.

The observational program which has been followed in making the measurements has been to make photometric readings with a Sharp-Millar photometer at elevations of 2°, 15°, 30°, 45°, 60°, 75° and 90° above the horizon on vertical circles at azimuth intervals of 45° beginning with the sun's vertical and proceeding half-way around the horizon. Only half the sky is measured because it is assumed that the

1 Kimball, H. H., and Hand, I. R.: Sky brightness and daylight illumination measurements. Sept., 1921, pp. 481-488.

brightness distribution is symmetrical about a vertical semicircle passing through the sun. Such measurements were made on days that were (1) perfectly clear, (2) overcast with thin clouds or dense haze, (3) completely overcast with clouds or dense fog, so that neither sun nor blue sky could be seen, (4) overcast with clouds from which rain or snow was falling, and (5) partly overcast, in an irregular manner.

On clear days it was found that the sky brightness at Washington has somewhat the following distribution: The brightest part of the sky is, of course, that close about the sun. The darkest part is that in the solar vertical about 90° distant from the sun. In general, the sky increases in brightness toward the horizon, although there is a "dark valley" extending from the dark point in the solar vertical to a point about midway between the sun and the horizon. This distribution agrees closely with that observed by Dorno at Davos, Switzerland, except that the Swiss sky is brighter than that at Washington. This difference in brightness is probably the result of secondary reflection of light from the Alpine snows. In comparison with observations made at Chicago University and on the roof of the Federal Building in "Loop" district of Chicago, it was found that the distribution there is much the same, except that the horizon opposite the sun is darker at Chicago than at Washington. This is attributed to smoke, from which the Washington atmosphere is particularly free.

The brightest type of sky measured at Washington is that completely overcast with thin clouds or dense haze. With clouds from which rain is falling, the distribution is about the same as with thin clouds, but its intensity is only half as great.

Measurements of the illumination on horizontal and vertical surfaces were made at Washington and at the two Chicago stations mentioned above. It was found with respect to the variations with change of solar altitude that the illumination on horizontal surfaces increased markedly with increase of solar altitude; but in the case of illumination on vertical surfaces the difference between a surface facing the sun and one oppositely directed grows less with increase of solar altitude. Moreover,

> The daylight illumination on a vertical surface facing opposite the sun, and with an unobstructed exposure to the sky, in the Loop district of Chicago under summer conditions as regards smoke, averages only about two thirds as intense as illumination on a similarly exposed surface at Washington under similar sky conditions with respect to clouds, except when the sun is more than 40° above the horizon and the sky is clear.

The equation,

$$\text{Tan } \theta = h/w\sqrt{1/(1 + \tan^2 x)},$$

is given for computing the shading effect of buildings on the opposite side of the street. θ is the angular height of a building as seen from the center of a window across the street, the width of the street being w. The horizontal angle between a normal to the window and a line joining a point p on the building opposite is x, and h is the height of the obstructing building above the point p. The author gives a table showing the relation between x and θ for various values of h/w. Attention is directed to the fact that the horizon is the most effective illuminating agent for vertical surfaces, hence buildings and other objects on the horizon are the most serious obstacles in the question of illuminating rooms through vertically placed windows, especially with a clear sky.

Two interesting examples of the relation between electric light load and sky brightness are given. At Washington, on July 15 and 29, 1921, there occurred thunderstorms about 2:30 p.m. and noon, respectively. On the former occasion, the daylight intensity fell rather quickly to about one foot-candle and the sudden increase in electric light load caused by the nearly simultaneous turning on of thousands of electric lights was sufficient to put the power plant out of commission. The statistician for the company states that

> During the day in the business section a sudden increase in current consumption occurs when the day light illumination intensity falls below 1,500 foot-candles. The lower the intensity, the higher the current consumption, but fluctuations in intensity above 1,800 foot-candles have only a negligible effect.

It appears that some arrangement whereby power companies supplying large cities could have recourse to observations of daylight illumination, especially during the thunderstorm season, would be of decided benefit to them, for the falling off of this illumination would afford an index as to the proper time to prepare to supply additional current.

This sketch is sufficient to indicate the character of the important work being done by Dr. Kimball and to suggest some of the industrial benefits to be derived from the study of daylight under various types of cloudy and smoky sky.

C. LE ROY MEISINGER

WASHINGTON, D. C.

ON STEREOTROPISM AS A CAUSE OF CELL DEGENERATION AND DEATH, AND ON MEANS TO PROLONG THE LIFE OF CELLS

IN former investigations we have shown [1, 2] that amoebocytes of Limulus have the tendency to move and to spread out in contact with solid bodies. We thus found another instance of a reaction which is common to many kinds of cells and which we observed and analyzed in 1897 and subsequent years and which we designated as stereotropism of tissue cells [3].

We further found that the blood cells of Limulus, as a result of this stereotropic response and the concomitant spreading out of their protoplasm along the surface of the solid body, underwent degenerative changes; they lost their granules, became hyaline and gradually motionless and then died. There was some indication that this spreading out of the cells was accompanied by a taking up of fluid from the surrounding medium and that this led to processes of solution which initiated the retrogressive changes. [1, 2, 4]

In order to prolong the life of these cells it was therefore necessary to retard this exaggerated stereotropic response which led to a spreading out of the cell in contact with the solid body. We found previously that this can be done not only by keeping the cells at a lower temperature, which retards other activities as well as the stereotropic reactions and is therefore not specific, but in a specific manner by enabling the cells to rest on a surface previously covered with a thin film of paraffine or vaseline. [4] In contact with such a surface the spreading out of the cells is considerably retarded and the life of the cells and the duration of their amoeboid movement is prolonged. In carrying out these experiments, we make use of the experimental cell fibrin (amoebocyte) tissue, a small piece of which we place on the prepared surface and surround with the desired kind of fluid.

Last summer at the Woods Hole Marine Biological Laboratory we continued these experiments with the cooperation of Mr. K. C. Blanchard [5] and found an additional method of preventing the extension of the cells and thus to prolong their life and activities. This can be accomplished by making the medium into which the cells enter from the piece of tissue very slightly acid, an observation which agrees with our previous finding according to which the cells perish in a neutral solution of isotonic sodium chloride, but are preserved in such solutions after addition of a very small amount of either acid of alkali.[2]

In our recent experiments we found that in such slightly acid media the cells leave the tissue in dense masses and continue to move for a considerable period of time; they are preserved, their spreading out is much retarded and their motor activity in consequence much prolonged. In alkali the cells are likewise preserved for some time, but they begin to spread out and become dissolved much earlier than in acid.

It is possible to grade the effect of acid upon the cells. If the acid used is too strong and

1 Leo Loeb, *Journal Medical Research*, 1902, II 145. *Virchow's Archiv.* 1903, Vol. 173, 35.

2 Leo Loeb, *Fòlia Haematologica* 1907, IV 313. *Pflüger's Archiv.* 1910 Vol. 131, 465.

3 Leo Loeb, *Archiv. f. Entwickelungsmech.* 1898 VI 297. *Anatomical Record* 1912, VI 109.

4 Leo Loeb, *Washington University Studies* 1920 VIII 3. *American Journ. Physiol.* 1921, Vol. 56 140.

5 These experiments will be more fully described by the writer and Mr. K. C. Blanchard elsewhere.

consequently the consistency of the cell too great, their motility is diminished. If it is used in too weak a concentration, the spreading out and solution processes are not sufficiently delayed. In an intermediate concentration of the acid, the consistency is such that the migration of the cells out of the piece is readily possible and at the same time the cells are preserved and the stereotropic reaction is retarded. But ultimately the cells begin to spread out and now retrogressive changes set in even in these favorable media. However, it may be possible to keep the cells active for six days or longer even at room temperature, at which under ordinary conditions the cells spread out and become hyaline on the first or second day.

In this case we recognize thus as the principal cause of cell death an extreme degree of reactivity of the cells in contact with solid surfaces. There is good reason for assuming that this reaction leads to an increased permeability of the surface of the cell which reaches a degree which is injurious and is thus responsible for the subsequent degenerative processes.

Conditions which prevent this extreme stereotropic reaction tend therefore to prolong the life of the cells. Acid acts in this way apparently by increasing the consistency of the cells, at least of its outer layer.

As we have shown elsewhere [4] there exists a striking analogy between the behavior of the amoebocytes and ordinary tissue cells. Through agglutination the amoebocytes produce sheets of a tissue-like material. After an incision in such a tissue cells migrate from the cut edge into the defect, in a way similar to tissue cells adjoining a wound. In both cases two factors determine the direction of migration: (a) The stereotropic reaction, (b) a tendency towards centrifugal movement.

During the process of movement the amoebocytes spread out and thus produce structures totally unlike the original amoebocytes, but closely resembling various tissues. A similar change from agglutinated round cells to cells spreading out in contact with a solid or viscous substratum underlies the embryonic tissue formation. Under the influence of mechanical factors a system of fibrillation can be produced in this experimental amoebocyte tissue which indicates the direction in which the mechanical factors act. In an analogous way we know that certain mechanical effects determine the fibrillation in certain higher tissues. In both cases the tissue formation leads to the production of an elastic tension under which the tissues are held, which latter retract after an incision had been made. The processes of tissue formation had led to the production of potential energy stored in the tissues.

The transformations which we observe in the amoebocytes in the case of tissue formation are, as far as our evidence shows at present, due mainly to two factors: (a) changes in consistency primarily in the outer layer of the cells; this depends in all probability upon a taking up of fluid from the surrounding medium and a different distribution of fluid within the cell, and (b) an increased permeability of the outer layer of the cell. These changes may lead to degenerative processes in the cell.

In some respects the differentiation and specialization of tissue cells in higher organisms has likewise the aspect of retrogressive changes; it may diminish the power of resistance of these differentiating cells. This suggests very strongly that changes of a similar character, although perhaps quantitatively weaker, may take place in the higher tissue cells during the process of tissue formation.

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THE AMERICAN CHEMICAL SOCIETY

(Continued)

DIVISION OF CHEMISTRY OF MEDICINAL PRODUCTS

CHARLES E. CASPARI, chairman.

EDGAR B. CARTER, secretary.

Arsphenamine and neoarsphenamine: GEORGE W. RAIZISS, JOSEPH GAVRON AND M. FALKOV. Arsphenamine and neoarsphenamine are indispensable in the treatment of spirochaetic infections. The elimination of the alarming symptoms or "reactions" attendant upon the use of these drugs is a problem of increasing importance. These have been attributed to chemical impurities which the authors have tried to identify. Incidentally, samples, of unusually high chemotherapeutic indices have been obtained. Methyl alco-

hol and crystallization have been found in two of the American made products. Experiments show that this does not exert any untoward effect upon the drug. A study of the colloidal properties and the relationship to toxicity has also been undertaken in order to explain the above "reactions."

Hydrogen peroxide, its manufacture and preservation: PAUL POETSCHKE. The quality of the chemicals needed and the equipment required for manufacturing the product and a detailed account of the various stages of the process are given. Briefly, the process consists in hydrating barium peroxide with distilled water and adding this mixture to a dilute solution of phosphoric acid which forms barium phosphate and hydrogen peroxide. Sulphuric acid is then added which regenerates the phosphoric acid converting the barium phosphate into barium sulphate and phosphoric acid. In this way the phosphoric acid is used over and over again. The insoluble barium sulphate and phosphate is then removed by filtration and the filtered hydrogen peroxide purified and adjusted to the proper strength. Experiments with quinine sulphate show that this substance has many advantages over acetanilid as a preservative, particularly in that only 1/10th the amount is required and it does not cause any foreign odor or discoloration. A mixture of benzoic acid and salicylic acid is also effective. Storage in glass bottles of suitable quality, and exclusion of light, are far more effective in restraining decomposition than any of the preservatives studied.

Developments in mercurial antiseptics: EDWIN C. WHITE AND JUSTINA H. HILL.

The preparation of certain arsenic-free reagents: G. D. BEAL AND K. E. SPARKS.

The preparation of pure fatty acids: G. D. BEAL AND J. B. BROWN.

The preparation of cholesterol esters of fatty acids: G. D. BEAL AND J. B. BROWN.

The determination of aldehydes in essential oils: FRANCIS D. DODGE. The use of bisulfite solutions in the technical determination of aldehydes is sometimes inconvenient, owing to the relative insolubility of the bisulfite compounds. The writer has found the solution of lithium bisulfite quite useful in such cases, the lithium compounds being in general more soluble than the sodium or potassium derivatives. A serious error arises, however, when unsaturated alcohols such as geraniol, linallol, or terpineol are present. The latter react slowly with bisulfite, yielding soluble sulfonic compounds and the aldehyde determination becomes quite inaccurate. Details are also given of experimental work with some other aldehyde reagents.

Crystalline ethyldihydrocupreine (optochin) base: MICHAEL HEIDELBERGER AND WALTER A. JACOBS. Hitherto only crystalline salts of ethyldihydrocupreine (optochin) have been reported. Having found that dihydroquinine could be advantageously recrystallized from toluene, we dissolved ethyldihydrocupreine in this solvent and allowed the solution to evaporate spontaneously, crystals forming after several days. On seeding a concentrated solution and letting stand the base separated as irregular leaflets containing toluene of crystallization, a portion of which was retained on air-drying, but could be removed by heating *in vacuo*. The base so obtained has approximately the properties of the purest commercial samples of the substance.

Crystalline ethyldihydrocupreine (optochin) base: MICHAEL HEIDELBERGER AND WALTER A. JACOBS.

The purification of tuberculin and the preparation of ophthalmic tuberculin discs: M. DORSET AND J. A. EMERY.

Food as a medicine: HARVEY A. WILEY.

The need for an improved formula for infusion of digitalis, U. S. P.: A. RICHARD BLISS, JR. In response to the complaints of clinicians concerning the unreliability, lack of uniformity, etc., of the Infusion of Digitalis of the U. S. Pharmacopoeia, a pharmacodynamic study of twenty samples of the Infusion was made. Fifteen of the samples were collected at random from retail drug stores, and five of the samples were prepared in the laboratory according to the unofficial method advocated by Hatcher and Eggleston. The method of pharmacodynamic assay employed was that known as the Hatcher and Brody Cat Method, a total of seventy-four estimations being made by this method. Ten of the drug store samples, prepared by the method of the U. S. P. IX, showed an average activity of but 38.1 per cent. of the theoretical activity; five of the drug store samples, prepared by diluting the fluid extract, showed an average activity of but 62.6 per cent. of the theoretical activity; and the five samples, prepared according to the method of Hatcher and Eggleston, showed an average activity of 95 per cent. of the theoretic activity. The dropping of the infusion as prepared by the present U. S. P. method, or the substitution of an improved formula, such as that

of Hatcher and Eggleston, is recommended by the author.

The toxicity of Benzyl alcohol and its homologues: OLIVER KAMM. The acute toxicities towards paramecia of homologues of benzyl alcohol agree well with the values predicted on the basis of experimental results obtained with aliphatic alcohols. Given the experimental value for one straight-chain aliphatic alcohol, the toxicities of the remaining members may be calculated by means of the "rule of thirds." The common branched-chain members also fit into the prediction scheme, two methyl groups in the form of side-chains being equivalent to one additional carbon atom in a straight-chain. To predict toxicities in the benzyl series it is simply necessary to apply in addition the previous presented "molecular volume relationship." Illustrative examples are presented.

Pharmacological examination of isopropyl alcohol: DAVID I. MACHT. Acute toxicity of isopropyl alcohol on intravenous injection in cats is greater than that of isopropyl alcohol; but is somewhat less than that of the normal propyl alcohol. The toxicity by mouth gives figures which run parallel to those for intravenous injection. Administration of small doses of isopropyl alcohol (2 cc per kilo) through stomach tube to dogs produced no marked permanent deleterious effects even when continued repeatedly over a number of days. Rats exposed to the fumes of isopropyl alcohol for a series of days showed no signs of poisoning. A large number of experiments performed for the purpose of ascertaining whether isopropyl alcohol would produce toxic symptoms after repeated applications to the skin yielded negative results. In common with other alcohols of the fatty acid series both normal and isopropyl alcohols are toxic for the isolated heart and excised muscle tissues. The effect on circulation is not much depressant in the *intact* animal when the drug is administered in smaller doses. Death after lethal doses is due in most cases to paralysis of the respiratory center but smaller doses produce no dangerous depression of the respiration.

SECTION OF SUGAR CHEMISTRY

C. A. BROWNE, chairman.

FREDERICK BATES, secretary.

Modified sulfate methods for ash in sugar and molasses: E. H. ADKINS AND J. R. WITHROW.

Some studies on decolorizing chars: C. E. COATES. A study was made of the possibility of making a decolorizing char for use in the cane industry from cane bagasse. The material was charred boiled with caustic soda and washed with hydrochloric acid and heated to 850 degrees. An excellent carbon was obtained by this method. Certain observations are given concerning methods for color comparisons with various types of tintometers and colorimeters.

The comparison of various carbons upon the American market: CHR. E. G. PORST AND JOHN M. KRNO. The decolorizing value of various carbons on the market was determined. By the use of steam activation and leaching and other means, carbons were produced from lignite, sawdust, spent boneblack and other materials. These were equal, and in some cases superior, as regards their decolorizing value, to those on the market. A method of grading the carbon was suggested.

Absorption isotherms of some decolorizing carbons: F. W. ZERBAN AND S. BYALL. Isotherms have been determined for the decolorization by six different decolorizing carbons of molasses solutions of varying concentration, and it has been found that, while for one carbon and one concentration the logarithmic curves closely approximate straight lines, there is a marked difference in the constants of the adsorption formula for one carbon at varying initial concentrations of molasses solution, and for the same initial concentration, using different carbons.

Mechanical clarification of cane sugar liquors: A. S. ELSENBAST. Cane sugar liquors are clarified and filtered without the use of chemical defecants by means of the specially prepared filtering medium, Filter-Cel. Details are given for operating with plantation white sugar, plantation white sugar by lime sulphur process, cane and sorghum syrups, raw sugar and standard granulated white sugar in cane sugar refineries.

Decolorizing carbons: H. H. PETERS AND F. P. PHELPS. Twenty different carbons have been used, under identical conditions, for the decolorization of one quality raw sugar, and some of them on the affined sugar and the raw wash resulting from the affination process. The effect is shown on the basis of spectrophotometric analysis which establishes new standards for a correct judgment, far more rigorous than at present accepted by technical colorimetric methods. The names of the carbons are withheld at this time. Not only does the quality of some carbons vary, but new equipment had to be ordered for a systematic and complete inquiry into the nature of the coloring bodies.

Comparison of the various corn product starches: CHR. E. G. PORST AND M. MOSKOWITZ. The Bingham-Green Plastometer is adapted to the examination of various corn starch pastes, alkali, acid and thin boiling (Herschel and Bergquist, Journal of Ind. & Eng. Chem., Vol 13, 703). A short review of the derivation of the formulas required is given. Type curves and tabulated data on the various starches investigated are included. The effect of the temperature of cooking on the properties of the pastes is noted and the need of more accurate formulas suggested.

An inquiry into fundamentals of sugar colorimetry: H. H. PETERS AND F. P. PHELPS. The spectrophotometric investigation of impure sugar products is continued, and the asbestos method of colorimetric clarification and filtration, which was reported in a previous paper, is further critically examined. Beer's Law is valid for concentrated impure sugar liquors (50 Brix), but dilution with water changes the degree of dispersion and colorimetric value of the colloidal non-sugars, invalidating Beer's Law. A new method, using concentrated granulated syrup of known spectral transmissivity for the dilution of heavily colored, concentrated syrups in place of water is presented.

The testing of quartz control plates: F. P. PHELPS. Quartz control plates are used in precise sugar work to eliminate all errors due to variations in the polariscope itself. All quartz plates sent to the Bureau of Standards are subjected to the following tests: (1) Examination of the mounting. (2) Homogeneity of the quartz. (3) Planeness of the faces. (4) Parallelism of the faces. (5) "Axis Error." (6) The precise measurement of the rotation from which the sugar value is calculated. A tentative set of specifications for quartz control plates has been drawn up as an aid in the production of plates of uniformly good quality. It is very important that all quartz control plates be standardized at some central agency such as the Bureau of Standards. The maker's value, which is stamped upon the mounting, can not be relied upon, in fact, plates have been tested at this bureau whose true sugar value differed from the maker's value by approximate 0.°2 of a sugar degree.

The origin and development of the cane sugar industry in America: C. A. BROWNE. The history of plantation cane sugar manufacture in America is briefly sketched with help of lantern slides and old engravings from 1493 down to the present day. The evolution of the mill, evaporator and other machinery is traced with descriptions of such curiosities as Stuart's steam mill and Bessemer's crusher. The methods of white sugar manufacture in Cuba by means of bone black between 1850 and 1860 are described. In conclusion the origin and development of the modern central system are discussed with particular reference to the future growth of the industry.

Enzyme method for determination of raffinose in beet sugar-house products: H. S. PAINE AND F. W. REYNOLDS. The method of Hudson and Harding, which depends on the hydrolysis of raffinose by invertase with formation of melibiose and fructose, and subsequent hydrolysis of melibiose by means of the enzyme melibiase, was adapted for the examination of beet molasses and other sugar-house products. The molasses solution is clarified with basic lead acetate and a small amount of norit, and, after suitable adjustment of the acidity, top yeast extract, containing the enzyme invertase, and bottom yeast extract, containing the enzymes invertase and melibiase, are added to equal portions of the clarified molasses. The difference in the polarizations is a measure of the amount of raffinose present. The success of the method depends upon the use of highly purified and concentrated enzyme preparations.

Rôle of fermentation in the deterioration of cane sugar products: C. A. BROWNE, C. A. GAMBLE, G. H. HARDIN AND M. H. WILEY. The average quality of the raw cane sugar manufactured in the tropics has shown but little improvement during the past five years. Only about 35 per cent. of the Cuban factories make good-keeping sugar of low moisture content. Sugars during deterioration become more hygroscopic, owing to the invert sugar that is formed, and the additional moisture absorbed from the atmosphere accelerates the activity of the destructive microorganisms. The chief requirements for making a good-keeping sugar are: (1) Cleanliness in the factory to prevent infection; (2) A moisture content sufficiently low to retard the growth of yeasts, moulds and bacteria; (3) Bagging the sugar after it has cooled to prevent sweating; (4) Storage in clean, dry warehouses in piles that are not high enough to burst the bags. The deterioration of soft refined sugars is less rapid than that of raw cane sugars of the same polarization. Sugar cane molasses also undergoes deterioration during storage with destruction of both sucrose and invert sugar.

The manufacture of chemically pure dextrose: C. E. G. PORST AND N. V. S. MUMFORD. The development of a method of manufacturing chemically pure dextrose using crystallization from water only is described. The first method used necessitated an alcohol wash and a crystallization from alcohol. This method had to be abandoned owing to excessive cost and another method developed. This method used "Cerelose" as a raw material and "Eponite" as a decolorizing agent. This method had to be abandoned to allow an increase in capacity. Boneblack is now used for decolorizing and the raw material is "Refined Cerelose" made by the Porst and Newkirk method. Difficulties encountered and methods of overcoming them are described.

The purification and concentration of enzyme solutions for the rapid analysis of sugars by enzymotic hydrolysis: F. W. REYNOLDS. Preparations of the enzymes invertase and melibiase were purified by dialysis followed by treatment with a very small proportion of acetic acid, which caused flocculation of impurities. Substances which stabilize the impurities flocculated by acetic acid are apparently removed by dialysis. This treatment is fully as efficient as clarification with neutral lead acetate and does not cause loss of enzymic activity. The filtrate may then be concentrated to practically any desired extent by ultra-filtration, using collodion filters of special composition. Highly active and brilliantly clear solutions of invertase and melibiase of great stability were thus obtained. This method of purification and concentration permits the use of these enzymes as analytical reagents, for rapid analysis of sucrose and raffinose. The construction of a suitable ultra-filter from materials generally available is described.

The estimation of raffinose and sucrose in beet products: R. F. JACKSON. A modification of the enzyme method permits an accurate determination of true raffinose without the difficulty of measuring small changes in polarization in the presence of large amounts of invert sugar. After sterilization of the molasses, the greater part of the invert sugar is removed by fermentation with bakers' yeast. The solution containing the melibiose is filtered, evaporated and divided into two aliquots, which are diluted one tenth, one with water, the other with the invertase-melibiase solution extracted from brewers' yeast. After hydrolysis, both are analyzed for reducing sugar. The difference between them is a measure of raffinose. The method is not standardized against pure raffinose. By the above method analyses were made of samples of Colorado beet molasses. True raffinose was found to be sometimes less and sometimes greater than that indicated by Clerget. From the true raffinose and true sucrose, the direct polarization of the sugars was computed. The difference between the calculated and observed direct polarizations give the rotation of the non-sugars. In every case these proved to be negatively rotating.

A simple diffusion battery for laboratory and lecture room experiments: M. J. PROFFITT. Each cell of the battery consists of a friction top tin can to the inner walls of which near the bottom is soldered a circular woven wire screen molded to a concave shape. A suitably bent copper tube is soldered with a perforation in the side of the can below the screen, and it extends on the outside above the top of the can, to connect with the juice line. It may be provided with a steam jacket for a colorisator. Two short copper tubes are soldered into perforations in the lid of the can, one for an air-vent and the other for connecting to the water-line. The juice, water and cross-over lines consist of glass T-tubes with rubber connections and pinch-cocks. A 14-cell battery without colorisators requires 14 friction top cans, enough wire screen to make the screens, depending upon the size of the cans used, about 60 pinch-cocks, 60 glass T-tubes, 20 feet of copper tubing, some solder, and 50 feet of thin-walled rubber tubing. At current prices, it will cost about $30 and require one day's time to set up. It serves for experiments on water extractions and for familiarizing students with the actual operation of the diffusion process as carried out in the manufacture of beet sugar.

Precipitation of gum from beet molasses: H. S. PAINE AND C. F. WALTON, JR. In order to permit a study of the properties of the gums present in beet molasses, and the effect of such gums on the analytical control and certain phases of the factory process, the following method of preparation was evolved. It is considered more rapid than the dialysis method previously described. Each kilogram of molasses is diluted with 10 liters of water, and to this solution are added 1.4 liters of ammoniacal lead acetate and 0.4 liter of strong ammonium hydroxide. After filtration of the precipitate, it is suspended in water and decomposed with 1:4 H_2SO_4 in carefully regulated amount. The filtrate is neutralized with solid barium hydroxide in the cold, concentrated in vacuo and dialyzed against running tap water.

This solution is clarified with neutral lead acetate, and after removing excess lead with H_2S the dialysis is completed against distilled water. The specific rotation of the gum obtained, on the basis of total solids in the purified solution, was $-38.°8$.

Chemical properties of the gum from cane affected by Cobb's gumming disease and its influence in the sugar-house: C. F. WALTON, JR., AND O. S. KEENER. Observations were made in Porto Rico of the effect of a gum similar to that from Cobb's gumming disease on factory operations. A somewhat concentrated solution of the gum purified by filtration and dialysis was found to polarize $-0.°6$ V. in a 2-decimeter tube. After hydrolysis with 1 per cent. hydrochloric acid this rotation changed to $+0.°1$ V. The solution after hydrolysis reduced Fehling's solution strongly but gave no test for pentose. Total solids by the Westphal balance corresponded closely to the amount found present by drying. Although the substance was found to be optically active, it was completely precipitated by basic lead acetate as in the usual method of analysis. On the basis of these and other experiments, it is believed that the presence of this gum in cane juice does not interfere with the laboratory analyses.

The dietetic value of sugar: W. D. HORNE. The extremely high food value of sugar is not adequately realized. As a producer of heat and energy in the body it is cheaper than almost any other food. With its high calorific efficiency, quick digestibility and present low price, it should logically be used in much larger quantities in old world countries where food and money are scarce. Europe averaged 37 pounds per capita per annum before the war. The United States now averages 86, and New Zealand in 1911 averaged 130. The United States could increase her consumption 20 to 30 per cent. advantageously and Europe much more.

Organic and inorganic composition of corn: C. E. G. PORST AND MISS J. F. MOHRING.

Some new processes in the sorghum syrup industry: J. J. WILLAMAN. The sorghum syrup industry is being given a new impetus by certain developments in its process of manufacture in a Minnesota factory. The principal ones are: (1) A cleaning machine, which does away with hand labor entirely in the harvesting and cleaning of the cane. (2) Instead of the wasteful settling process of clarification, the whole juice, after defecation with heat and lime, is filtered, infusorial earth being an ideal filtering medium. (3) Treatment of the filtered juice with activated charcoal produces a light colored, mildly flavored product. (4) Evaporation in a vacuum. (5) The seed heads are dried and constitute a valuable by-product. (6) The leaves and bagasse are continuously fed into the fire-boxes, and constitute 85 per cent. of the fuel. (7) The cleaner has reduced the labor hour cost per gallon of syrup from 1.3 hours to 0.7 hour. (8) The cheapening of the processes, the improvement of chemical control, and the breeding of pedigreed and improved cane, have inaugurated a new era in sorghum syrup manufacture.

Note on the first uses of the polariscope in the United States for sugar testing: C. A. BROWNE. A search of available records indicates that one of Biot's early polariscopes was used in the sugar refinery of J. S. Lovering & Co. in Philadelphia as early in 1843. Two Ventzke polariscopes were imported about the same time, one by the chemical firm of Booth & Boye of Philadelphia, and one by Professor R. S. McCulloh, of Jefferson College, for his research upon sugar and hydrometers for the U. S. government. Information is lacking as to the date of the importation of the first Soleil saccharimeter. An old Soleil instrument used by Valcour Aime of Louisiana and now in the Louisiana State Museum is probably of about the date 1850.

Preparation of fructose from invert sugar: T. SWANN HARDING. Fructose was prepared by fractional crystallization from invert sugar obtained by the hydrolysis of sucrose by invertase. It was found necessary to recover by the first crystallization 36 to 37½ per cent. of the weight of sucrose taken as glucose. The yield of fructose subsequently crystallized amounted to 23.5 to 28 per cent. of the weight of sucrose taken. The sirups were mixed with glacial acetic acid before setting aside to crystallize. The fructose was recrystallized from alcohol. The effect is discussed of various factors, such as acidity and temperature, on the crystallization of fructose.

Analyses of mixtures of reducing sugars and sucrose with Quisumbing's Fehling solution method. A. W. THOMAS. Analyses of known sugar mixtures containing sucrose give more nearly correct results when using the new Fehling reduction method than has been possible by any of the older reduction methods.

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Secretary